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## *THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE*

## *ENGINEERING AS A PROFESSION AND ITS RELATION TO THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE*[1]

IN considering what should be the topic of my brief address as retiring Vice-president of Section D of this association, the question of the relation of the profession of engineering to this association has been forcibly brought before my mind. A number of engineering subjects of interest suggested themselves, in regard to which I might perhaps be able to present to you ideas more or less novel and interesting; but all these subjects seemed, upon consideration, better suited to one of the professional engineering societies. I have therefore concluded to ask your attention for a few minutes to a consideration of the profession of engineering itself and its relation to the American Association for the Advancement of Science.

I do this, in the first place, because the profession is one in the standing and recognition of which I have the deepest personal interest, and, in the second place, because I have even within a few months been made to realize that many well informed people deny that engineering is a profession at all or the engineer a professional man in the proper sense of the term; and, in the third place, because the relation of the profession to this association seems to have long been a matter of doubt and

[1] Address of the vice-president and chairman of Section D—Mechanical Science and Engineering. American Association for the Advancement of Science, Boston, December 29, 1909.

uncertainty. Many people seem to think that the engineer is neither a scientist nor a professional man, nor yet a business man strictly speaking, but that he is something betwixt and between—some one to be employed for certain technical work.

According to the dictionary, a profession is defined as "a vocation in which a professed knowledge of some department of science or learning is used by its practical applications to the affairs of others, either in advising, guiding or teaching them, or in serving their interests or welfare in the practise of the art founded on it. Formerly, theology, law and medicine were specifically known as the professions, but as the applications of science and learning are extended to other departments of affairs, other vocations also receive the name. The word implies professed attainments in special knowledge as distinguished from mere skill; a practical dealing with affairs as distinguished from mere study or investigation; and the application of such knowledge to uses for others as a vocation as distinguished from its pursuit for one's own purpose.

Up to the present time the art involved in the work of engineering has been more recognized than the science. The engineer has been considered rather a builder than a scientific man, pursuing an occupation rather than a profession.

At a meeting of the council of the Institution of Civil Engineers of Great Britain held on December 29, 1827, it was *Resolved;* that Mr. Tredgold be written to, requesting him to define the objects of the Institution of Civil Engineers, and to give a description of what a civil engineer is, in order that this description and these objects may be embodied in a petition to the Attorney General in application for a charter." At the following meeting of the council, on January 4, 1828, a communication from Mr. Tredgold was read and entered in the minutes, bearing the title: "Description of a Civil Engineer, by Thomas Tredgold, Hon. M.Inst.C.E.," as a result of which the charter of the institution describes the profession of the civil engineer as "the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states for both external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange; and in the construction of ports, harbors, moles, breakwaters and lighthouses; and in the art of navigation by artificial power for the purposes of commerce, and in the construction and the adaptation of machinery, and in the drainage of cities and towns."

Since Tredgold's time, however, fields then unsuspected have been added to the profession of engineering, amply justifying the prediction that he made, that the extent of the profession "is limited *only by the progress of science,*" and that "its scope and utility will be increased with every discovery in philosophy, and its resources with every invention of the mechanical or chemical arts, since its bounds are unlimited, and equally so must be the resources of its professors."

But in order to sketch even inadequately the scope of engineering, I must ask you to follow with me briefly the historical development of the profession.

The vocation of engineering is as ancient as any of man's occupations. No doubt from the earliest times man has been subject to disease, and *the healing art* in more or less crude form has been practised; man, naturally a quarrelsome animal, has also from the earliest time engaged in disputes with his neighbors, and in more or less crude form the *law* has had to be ad-

ministered; and, once more, from the most primitive times, man has realized the presence of some supernatural power, which the *priest*, if only under the title of "medicine man," has endeavored to propitiate. But clearly, man has always required water and food, and has dug wells and employed crude means for raising water and of growing crops. He has also needed habitations, and has required the services of men to build them, so that the hydraulic and the structural engineer or architect may at least claim that their profession is as old as any.

As civilization developed, the work of the engineer or builder developed equally. The Assyrians and Babylonians built arches and bridges, the inhabitants of India built great reservoirs, the Egyptians built pyramids, the Romans built roads, bridges, aqueducts, baths and other important works, many of them of great extent and requiring great skill. But when we read that the construction of one of the pyramids of Egypt required the labor of 360,000 men for twenty years, we see that the work of the engineer was not precisely directed to the uses of others, and we realize the crudeness, in some respects, of the civilization which would permit such waste of useful effort. During the middle ages, with the neglect of learning, engineering declined, but with the revival of learning in the sixteenth century it took on new life, and since that time, with the advance of science, it has progressed probably more rapidly than any other field of activity.

During the early development of the profession, engineering came to be divided into two kinds, civil and military, the latter being concerned with fortifications and with means of offense and defense, while the former included all other applications of the building art. Up to nearly the end of the eighteenth century, Tredgold's definition was somewhat inapplicable, inasmuch as the *sources of power* in nature were not understood, and could be utilized only to a very small degree. Up to that time, engineering comprised mainly the construction of roads, canals and bridges, the improvement of harbors, river works, the construction of docks, and the supplying of towns and cities with water. The state of the art only allowed of the construction of bridges of very short span, of either stone or wood, since iron had not yet been brought into use, and ferries were generally employed in crossing streams too deep for fording. The steam engine was known only in a very crude and uneconomical form, the weaving of cloth was almost all done by hand, there was little transportation except by sea, cities were not drained or lighted by gas, the applications of electricity were, of course, unknown, navigation by water was entirely by means of sailing vessels or with oars, and the only form in which iron was used to any extent was in the form of cast iron.

But before the end of the eighteenth century there came a remarkable series of mechanical inventions—the spinning jenny by Hargreaves, the spinning frame by Arkwright, the mule by Crompton, the power loom by Cartwright, the modern steam engine by Watt, the puddling process for making wrought iron by Cort, and others. These were followed, in the first third of the eighteenth century, by the development of the steam locomotive by Stephenson, of the steamboat by Fulton, by the inauguration of the era of railroads, beginning for all practical purposes with the victory of the "Rocket" in the competition at Rainhill in 1829, and by the further great improvements in manufacturing, and in the production of iron and steel.

It was just at this time, when the minds of all were filled with the inventions of Watt and of Stephenson, that Tredgold gave his definition, clearly showing the tremendous influence held at that time by the subject of *power*. These great developments greatly enlarged the field of engineering, and gave birth to a new class of engineer—the railroad engineer. They led also to the differentiation of the mechanical engineer from the civil engineer. Since that time the mechanical engineer has claimed as his special field the development and use of power in all its forms, including the generation of power from the combustion of fuel and the flow of water, by means of the various types of engines and water wheels, the transmission of that power from point to point by means of belting, shafting or other means, and the utilization of that power by machinery. There is hardly a field of human industry, therefore, which is not dependent upon the mechanical engineer, because all manufactured articles depend upon power in some application, and upon machinery operated by power. The field of the modern mechanical engineer, however, not only covers the department of power and its applications—in manufacturing, in the steam locomotive, in the steamship—but it is also held to include the construction of mills, and all applications of steam and heat, such as heating, ventilation, lighting, refrigeration, ice making, elevators and so on.

But notwithstanding the differentiation from it of the field of the mechanical engineer, the field of the civil engineer was itself enlarged by the progress of science and invention. The great impetus given to manufacturing rendered necessary the distribution of the raw material and of the manufactured products. Transportation engineering was enormously increased in its scope, and the new profession of the railroad engineer was brought into existence. Roads and canals, harbors and docks were built with unexampled rapidity and river improvements were extensively carried on. At this time the increasing use of canals gave occasion for the celebrated remark of Brindley, the great canal engineer of England, himself an untutored genius, who, when asked what the use of a river was, replied "to supply canals with water." At the same time the economical production of wrought iron rendered possible the construction of bridges of unexampled span.

By this time had begun one of the greatest sociological movements which characterizes the present time, namely, the increasing congregation of people in cities. At the beginning of the nineteenth century only 3 per cent. of the population of the United States lived in cities, while at the present time the urban population is over 33 per cent. of the total. This phenomenon, during the last half of the century just passed, has led to the differentiation of another field of engineering, namely, that of the sanitary engineer, whose specific province it is to deal with the problems of water supply, drainage, the disposal of refuse, the purification of water and sewage, the sanitation of dwellings, and the various other problems resulting from this congestion of population.

Improvements, also, in chemistry and in metallurgy, have given rise to still other distinct branches of engineering, namely, mining engineering and metallurgy, the scope of which I will not endeavor here to sketch.

Again, the field of the mechanical engineer has during the past quarter of a century become subdivided, owing to the discoveries in electricity. Steam and water are no longer used simply to propel steam

engines or water wheels, producing power to be used on the spot. Steam or other engines, and water wheels, now drive electric generators, the currents from which are transmitted long distances, sometimes as great as 200 or even 300 miles, by means of transmission wires, to be again transformed by electric machinery and used for the production of light or for other purposes. The telephone and the telegraph have been discovered, electric cars have replaced the horse cars, and the passenger traffic of our steam railroads is in some cases being carried on by electric locomotives. Almost everything now-a-days *is* done or *can be* done by electricity, even to preparing our food and heating our houses. The electrical engineer, with a field already so wide that it is divided into specialties, is a product of the last twenty-five years.

Notwithstanding all these differentiations, even the field of the civil engineer keeps on increasing in scope. Coasts have to be protected from the sea, swamp and marsh lands reclaimed, large areas irrigated by artificial means, requiring the construction of great dams, the storing of immense quantities of water and the distribution of that water by means of canals into the uplands. Problems of urban transportation present themselves and must be solved by the construction of subways and tunnels, great railroad terminals have to be provided, and skyscrapers constructed.

Also, the development of electrical power, and the increasing scarcity and waste of fuel, has increased enormously the importance and value of water powers. The question of the discharge of rivers, the means of increasing it, of storing it so as to make it more regular from month to month, thus avoiding the damage due to floods, and increasing the power during dry seasons, the construction of dams and of the various works incident to the development of water powers, all these together with other problems now constitute a separate field, that of the hydraulic engineer. Water, at once the most valuable and necessary of the gifts of nature, and at the same time an enemy to be dreaded and feared, must be controlled and governed, so that communities may be supplied adequately with this necessity of life and the power generated by the rivers turned to the service of man. The laws of water flowing in conduits, through pipes and in open channels, must be studied and experimented upon, and the science of the laws of water—hydraulics—is steadily increasing in value and in importance.

But the field of the engineer is not yet exhausted. The increase in transportation by sea, the use of steel for ships, and the ever-increasing size of vessels, led to the profession of the naval architect, itself a large field, dealing with the applications of steel and other materials to the construction of vessels, and the proper equipment of these vessels. The naval architect builds the vessels, the marine engineer equips them with machinery and provides them with ventilating and other apparatus necessary to fit them for their use.

Finally, investigations in the various fields of applied chemistry, as for instance in the production of gas, in the manufacture of rubber, soap, glue and other materials too numerous to mention, have led in recent years to the formation of still another branch of the profession, namely, that of the chemical engineer, who deals with the applications of chemistry to the useful arts. To even enumerate the application of this science would tax your patience.

It will be evident from the foregoing brief review, that the field of engineering

is more extensive than that of any of the three so-called learned professions, and that the different branches of the profession differ from each other to such an extent as in some cases to have little in common, except a knowledge of the general principles of physics, chemistry, mechanics and other sciences. The profession of the physician, it is true, is divided into many specialties, but while the throat specialist deals with the throat, and the stomach specialist with the stomach, they are all dealing with the human body, in which all the parts and functions are closely interconnected; but even within the field of what is termed civil engineering, the railroad engineer and the irrigation engineer, or the railroad engineer and the architectural engineer, have little in common. Assuredly Tredgold was right when he said that the bounds of the profession are unlimited.

The work of the engineer as applied to any contemplated project consists essentially of four parts: first, to ascertain whether anything should be done, and if so, what should be done; second, to design and formulate the means to be employed in doing it; third, to select the proper materials; and, fourth, to carry on the actual work into execution. As the engineer's problem is to adapt the materials, the forces, the sources of power in nature to the use and convenience of man, it is clear that in order to fulfil his calling to the highest extent, the engineer should be scientifically trained, that he should be familiar with the fundamental principles which govern natural phenomena. Different branches of science are required in varying degrees in the different branches of the profession, but every engineer should know, and know thoroughly, the fundamental principles of chemistry, physics, mathematics and mechanics. The engineer should be possessed of the true scientific spirit, loving the study of science for its own sake as well as for its applications and trained to seek always the truth, the whole truth and nothing but the truth. But the work of the engineer deals not with science for its own sake, but with its applications to the practical affairs of men. The engineer must, therefore, be above all a *practical man.* He must not be a pure theorist, a dreamer, a visionary. He must see in his mathematical formulæ a meaning, and not a simple accumulation of letters. The engineer, then, must not only be a scientific man but he must be first and foremost a practical man. And on the whole, the latter is more important than the former, although it is in the proper combination of the two that the greatest excellence will result.

The engineer, unlike the true scientist or mathematician, does not work in his laboratory or his study; his work is with the affairs of men. Engineering is more than half business, and the successful engineer, therefore, must be to a considerable extent a *business man* and a *financier.* As already remarked, the most important problem, and the first he has to solve, is whether anything should be done in a given case, and if so, what? The engineer must not build a fine bridge with costly peculiarities, difficult to execute, for the sake of leaving a monument behind him. He must continually remember that engineering is not simply adapting the forces of nature to the use of man, but that it is adapting them economically and properly. More important than the question *how* a bridge shall be built is the question *whether* it shall be built. More important than the question *how* a railroad shall be located is the question *whether* it shall be located and *where* it shall be located. The decision of these questions requires finan-

cial and business ability of a high order, combined with a clear insight into the practical relations of things. The railroad engineer must study the manufacturing and economic conditions affecting a country through which a proposed railroad is to pass; he must consider the traffic on existing roads through that country, the relative importance of the cities, whether there is a possibility of increasing the agricultural or manufacturing product, whether the road should run in a comparatively straight line between two large towns or whether it should be diverted a number of miles in order to tap a smaller town or whether that smaller town should be reached by a branch from the main line; and many similar questions. It is clear that Tredgold's definition is faulty because it does not emphasize economy.

It is also evident that the engineer should have the large view. He has the opportunity to worse than waste the money of his employers. The engineer who concentrates his whole attention on details of construction may be a good subordinate—and even good subordinates are rare—but he will lack the essentials of the highest success.

Even after the construction of works is entered upon, the duties of the engineer will largely relate to business. He draws up the contracts for the work, estimates each month how much has been completed, certifies payments to the contractor, settles disputes, and in general attends to all the business, except legal matters, connected with the carrying out of the enterprise. He must be an organizer, and must know how large a force is necessary to superintend the work, and how to dispose it to the best advantage and with the greatest economy. It is evident, also, and this is extremely important, that the engineer must be a student of men—not a recluse, but a man among men; and upon his social qualities, upon his ability to get on tactfully with other men and his power of impressing his ideas upon others, will his success largely depend.

One of the most important functions of the engineer is to be able to determine the proper materials to use in his work, to know how to obtain them, and to know how to assure himself that he has obtained them. This function includes a wide range of scientific and practical knowledge. He must not only know the mechanical, chemical and physical properties of materials, such as building stones, timber, steel, iron, cement, paint, asphalt, etc., but he must know what particular material is best adapted to the particular work he has to do, and how to test it and so make sure that the desired qualities are obtained. Probably more engineering failures have been due to faults of material than to any other defect, although it is a common mistake of students to suppose that the work of the engineer is largely the designing of works by the use of mathematical formulæ.

It is evident from the foregoing that not only is the profession of the engineer a wide and varied one, but that it requires varied qualifications, and demands preeminently an all-round man. It must not be forgotten, however, that without the scientific training, or at least the scientific spirit, the engineer will not attain the highest success. It is also evident that the thoroughly trained and capable engineer will find many opportunities to make himself useful in scientific as well as in administrative positions. He will also find many opportunities for doing general public service to the state or nation. Different men have different ideals of success, but the highest ideal is the one which most involves the idea of public service. We have heard a great deal about our natural re-

sources and, indeed, we in this land have been favored in an exceptional degree. We have already done much toward the development of these resources. Our industrial progress in the last one hundred years has been unexampled. But with this great development has gone great waste and extravagance. Our natural resources are being dissipated at a rate which will cause the disappearance of many of them within a comparatively few years if the waste is not checked. To elaborate this subject would require a long time, but you may not be aware of the fact, to cite but one instance, that natural gas is to-day being wasted in this country to such an alarming extent that the waste would be sufficient to light every city in the United States having a population of over 100,000. The engineer is the man who *applies* the resources of nature. He must be the man who also *conserves* those resources. It is probably safe to say that upon him, more than upon any other man, depend the continuance and increase of our prosperity.

The law, medicine and theology have always been considered as the *learned* professions. They are the vocations for which men have been honored *on account of their brains*. After what has been said is it not clear that the engineering profession can claim this distinction to fully as great a degree? Assuredly, such would seem to be the case. But while the three so-called learned professions have been recognized as such for centuries, the profession of engineering, as already said, is the product of the last century and a half. For this and other reasons, it has not been recognized in the popular mind to the extent which its intrinsic importance and the excellence of its work justifies. This is, of course, perfectly natural. In the early days of engineering, centuries ago, the engineer was usually a man engaged also in some other vocation, frequently that of architecture, but sometimes that of the statesman, administrator, mathematician, lawyer, soldier or even priest. Archimedes was a mathematician, but he also built canals in Egypt and in his last days devoted his scientific knowledge to the defence of his native city of Syracuse against Marcellus. The Emperor Trajan built a remarkable bridge across the Danube; and Julius Cæsar built one across the Rhine; Leonardo da Vinci was not only poet, painter and sculptor, but also a civil and military engineer; and during the middle ages the building of bridges in Europe was undertaken by a monastic order known as the Brothers of the Bridge.

I maintain that the preceding discussion fully establishes the fact that engineering is a profession, that the engineer in the highest sense is a professional man, and further that he should be a scientist at heart. It is equally clear, however, considering the relation of the profession to business that many engineers may be purely business men, practising engineering not in the truly professional sense. This, however, is also true of the law, as many examples might be quoted to illustrate.

When this association was organized in 1848, the great development of engineering which has been sketched in preceding pages was just beginning, but had not progressed far. There were few engineering schools or engineering societies. In this connection the growth of engineering schools and of engineering societies is interesting. The oldest engineering society in this country is the Boston Society of Civil Engineers. It was organized July 13, 1848, and incorporated April 24, 1851. It held sessions until 1856, after which there was a gap until 1874, so that it is

really only during the past thirty-five years that the modern society has existed.

The American Society of Civil Engineers was founded in 1852 and held meetings until 1855, when there was a gap until reorganized in 1867. This society now numbers 4,847 members in all grades.

The American Institute of Mining Engineers was organized in 1871, the American Society of Mechanical Engineers as late as 1880 and the American Institute of Electrical Engineers in 1884.

In England, the first society of engineers was a club organized in 1771 by Smeaton and a few others who met at a tavern. Twenty years later it consisted of nearly twenty members, but of these only fifteen were engineers. A personal difficulty broke up the club, but it was reorganized a year later and existed as late as 1872.

The present Institution of Civil Engineers was an outgrowth from this society and was established January 18, 1818, the renowned Telford being the first president and holding that office from 1820 to 1834. Telford built roads and bridges, canals, river works, docks and lighthouses, drained fens and reclaimed the land from the sea. The railroad era was just beginning, and also that of the water supply, gas lighting and drainage of cities. In the time of Telford the institution never numbered more than 200 members, but between 1840 and 1860 two of the leading English railroad engineers, Robert Stephenson and I. K. Brunel, probably each had a corps of trained engineers under his control as large as the whole membership of the institution in its early days. The institution now has a total membership of 8,627 in all grades. This institution was the first professional body to publish discussions of its papers, others, like the Royal Society, publishing only the papers themselves.

At the time of the declaration of independence there were only two professional schools in the United States—the Medical College in Philadelphia (afterwards the Medical School of the University of Pennsylvania) and the Medical School of King's College (afterward Columbia University). The Harvard Medical School was established in 1782 by the appointment of Dr. John Warren as professor of anatomy and surgery. During the last century, medical schools sprang up with great rapidity, both connected with universities and independent, many of them with very low standards. In 1870, Harvard was the first to demand a new and much higher standard, followed only a few years ago by further raising the standard by requiring a college degree, or its equivalent, for entrance.

The first law school in America was not connected with any college and was established in 1784 at Litchfield, Conn., but was discontinued in 1833. The Harvard Law School was established in 1817, being the earliest connected with a university and authorized to confer degrees in law. In 1897 it was made a graduate school for which a college degree was required for entrance, or a degree of proficiency sufficient for entrance into the senior class at Harvard.

The Yale Law School was established in 1824; that of the University of Virginia in 1825, of the University of Cincinnati in 1833 and of Columbia University in 1858. In 1878, there were fifty law schools in the United States with a total of 3,012 students; in 1901 there were 86 law schools with a total of 11,883 students.

The first engineering school in this country was the Rensselaer Polytechnic Institute at Troy, which was organized in 1824. The Lawrence Scientific School of Harvard and the Sheffield Scientific School of Yale were organized in 1847, and these

were followed during the next twenty years by the Massachusetts Institute of Technology in 1865 and other institutions. Since that time, the number of schools and students has greatly increased, as shown by the following statistics relating to professional schools in 1905:

| | Theological Schools | Law Schools | Medical Schools | Schools of Technology Conferring only B.S. Degrees |
|---|---|---|---|---|
| Number of institutions... | 156 | 96 | 148 | 44 |
| Teachers....... | 1,094 | 1,190 | 5,465 | 1,865 |
| Students....... | 7,580 | 14,714 | 25,835 | 16,110 |

The engineering *societies* do not in any case require a technical training as a preparation for membership. The American Society of Civil Engineers requires for full membership that the candidate shall be at least thirty years of age, shall have been in the practise of his profession for ten years and shall have had responsible charge of work for at least five years. Graduation from a technical school is considered equivalent to two years of practical work.

A good illustration of the development of the engineering profession is found in the history of the noted French corps of government engineers known as the Corps des Ponts et Chausseès. It was in the time of Charles V. that professional engineers were first employed by the king to supervise public works, particularly roads, which were known as the king's highways. The corps experienced many vicissitudes, some rulers appreciating their work while others did not. In the time of Louis XIV., the engineers were pushed into the background, the king reserving his favor for the court architects. The architect, Mansard, was entrusted with the building of a bridge across the Allier at Moulins, but he was unacquainted with the principles of hydraulics and could not calculate the volume and force of the water, and did not know how to protect his bridge against floods, so that it collapsed a few years later. This disaster was favorable to the engineers, who pointed out that while it was the duty of architects to build fine palaces, engineers should be entrusted with the construction of public works where convenience and stability were of more importance than elegance. The Corps des Ponts et Chausseès was definitely and permanently organized between 1712 and 1716; and under Louis XV. the noted Ecole des Ponts et Chausseès was constituted by royal decree dated February 14, 1747. It was placed under the direction of the engineer Perronet, who besides other great works had built the beautiful Pont de la Concorde at Paris. At the beginning of the French Revolution, it was proposed to abolish the corps, but this move was defeated by Mirabeau, and, instead, the corps was reorganized by several decrees. The corps is now under the department of public works. Five sixths of its engineers come from the Ecole des Ponts et Chausseès, while one sixth come from foremen, who, after ten years' experience, are entitled to enter a competitive examination and if successful may be appointed engineers.

Perronet remained director of the school for forty-seven years after it was founded in 1747. He died February 27, 1794. The following year the Ecole Polytechnique was founded, giving a general scientific training preparatory to the engineering school. The course in the engineering school extends over three years, offering free tuition in all courses, and state pupils are chosen exclusively from those leaving the Ecole Polytechnique and receive a salary of $360 a year plus $10 monthly during their stay in Paris. During each vacation they are required to spend three and one half

months in practical work under the supervision of one of the engineers of the corps.

From these statements it is evident that engineering schools are of later growth than those in the other learned professions, which in Europe have been established for centuries, and in this country long antedated the technical schools. It is also clear that engineering societies are mostly of more recent origin than this association, and that they do not insist upon a technical or scientific education as a qualification for membership.

It is clear from what has been recited that with the great development of applied science, or engineering, has gone a corresponding development of engineering societies. Each separate branch of engineering is represented by a national society, and there are numerous smaller local societies. While in the old days the American Association for the Advancement of Science may have had attractions for engineers, and may have given them opportunities for scientific discussion of papers not otherwise to be obtained, even this is questionable, and it certainly is not now the case. It is safe to say that important engineering papers will not be presented to this society, or if so presented, will fail to be of their due influence. Section D, however, or what has corresponded to it, does not appear to have ever been of great importance in the American Association for the Advancement of Science. I have examined the records of the association from the beginning and it appears that few, if any, engineering papers of importance have been presented to it, except by title or on abstract, and that these have often been presented in full before professional engineering societies, or in the engineering papers. A majority of the papers before this section have been presented by a very small group of men, including professors in a few engineering schools and some men holding government positions. For many years no papers have been printed in full except the vice-presidential addresses, and in many instances the other papers have all been printed by title only. Even in the early days, or up to 1880, there were many years in which but one paper on applied science was presented, and there were nine years in which no such paper was presented. Section D was first constituted in 1882, although previous to this date the section of mechanical science had been recognized as a branch of the section on mathematics and physics. About this time Professors Trowbridge, Thurston and others began to take some active interest in the society, and their names with those of Burkitt Webb, Wood, Denton and some others are frequently seen in the list of authors, although none of their papers are printed in full in the proceedings. In five years since 1882 there have been no vice-presidential addresses; in the majority of the cases such addresses, like the present one, have not been upon engineering or even scientific topics, but have been distinctly general or educational in character. The attendance at the meetings of the section has, from what information I have been able to gather, been small, and the future of the section has long been a matter of doubt. Professor Storm Bull, in his annual address in 1899, expresses his regret at the somewhat prevailing feeling that the extinction of the section is imminent.

What, then, is the function of Section D as related to the profession of engineering? Has it a useful purpose to subserve?

As a comparatively new member of the association, I venture an opinion on this subject with diffidence, yet as an engineer of some years of experience, and with a somewhat close knowledge of a number of strictly professional societies, possibly it

may be proper for me to do so. In the first place, I confess that when I joined the society I did so not because of its relations to engineering, but because of my interest in some branches of science; not primarily in order to meet engineers or to hear engineering papers, for these ends can much better be obtained in connection with the professional societies, but to have the opportunity to meet men interested like myself in the various branches of pure science. I believe that the membership of this section will in the future, as in the past, consist largely of teachers of engineering who like myself recognize that the profession of engineering is founded upon the principles of science, and who desire to keep alive their interest in and contact with those scientific branches; and that the section can never become an effective means for the discussion of technical engineering subjects. From this point of view, then, I believe that the main benefit of this section, which I hope will continue, will arise in two ways: In the first place, it will be beneficial if its main activities are directed not toward technical engineering subjects, but toward subjects which are more scientific than technical. For instance, the subject of geodesy has not yet been made the basis of a national engineering society in this country, and, indeed, that subject is probably quite as much allied to the science of physics as it is to engineering. Such a subject might well be made a specialty of this section, for it is rarely that we find a discussion of geodetic subjects before any of the engineering societies.

Again, the subject of aeronautics, which I am pleased to see has been made an important feature of the present meeting of this section, seems a peculiarly appropriate field. It is perhaps a fair statement that this subject is as yet more a scientific and experimental one than an engineering one; at all events, it has not yet been taken up to any considerable extent by the engineering societies. Subjects, then, more purely of a scientific character and yet of such concrete nature that they are capable of practical utilization, or may form the basis of engineering applications, may well be emphasized in the meetings of this section.

We must remember that for the engineer, science will in most cases simply afford him a basis for his judgment rather than give absolute results. You have discussed this morning questions regarding the wind and the variation of its velocity and pressure with the height; but no matter how many observations you may make, or how many theories you may formulate, the engineer will still have to depend upon his judgment in providing for the wind pressure upon a modern skyscraper or Eiffel Tower.

In the third place, if I am right in considering that the members of this section, like myself, have their principal interest in the society because of their interest in certain branches of pure science, it would seem that the section might be of benefit if it could hold joint meetings frequently with other sections, and instead of attempting to present a long array of papers, should content itself with a very few having distinct relation to some particular topic assigned to the meeting. Certainly no session has been more interesting or, in my opinion, more profitable, than the joint meeting in Chicago, two years ago, with the mathematical section. Engineers, and particularly teachers of engineering, have, or should have, much in common with teachers of mathematics, chemistry and physics, and even with those in still more distantly related sections. And men in those other sections have, or should have, not less to gain from intercourse with us. My plea, then, is that the main benefit of Section D is not to be derived from its

activity as an association of engineers, that is, as a strictly or even quasi professional organization, but from its relations with the other sections, and that its own activities might well be somewhat curtailed if more intimate relations could be initiated and stimulated with those other sections; and that it should endeavor to present to its members not technical engineering subjects, but rather scientific subjects in branches seldom discussed in the technical engineering societies. Let us remember, then, that engineering is a profession, but that it is founded upon science; that the engineer should be at heart a true scientist, and thoroughly imbued with the scientific spirit. Further, that this association is not a professional society, but a scientific one, and that we come here rather as scientists than as engineers; that through our meetings and our contact with scientists in all branches, we may go forth to our daily practical and business work more thoroughly imbued than ever with a sense of the importance of our profession, and better able to apply economically the materials, forces and laws of nature in the service of man.

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## *THE CHEMICAL REGULATION OF THE PROCESSES OF THE BODY BY MEANS OF ACTIVATORS, KINASES AND HORMONES*[1]

AT the time of Sir Charles Bell physiologists were beginning to realize the great importance of the nervous system as a mechanism for regulating and coordinating the varied activities of the body. To use his own expression, "The knowledge of what is termed the economy of an animal body is to be acquired only by an intimate acquaintance with the distribution and uses of the nerves." Since his time experimental investigations in physiology and clinical studies upon man have combined to accumulate a large fund of information in regard to the regulations and correlations effected through nervous reflexes. No one can doubt that very much remains to be accomplished along these same lines, but in recent years we have come to understand that the complex of activities in the animal body is united into a functional harmony, not only through a reflex control exerted by the nervous system, but also by means of a chemical regulation effected through the blood or other liquids of the organism. The first serious realization of the importance of this second method of regulation came with the development of our knowledge of the internal secretions during the last decade of the nineteenth century. The somewhat meager information possessed at that time in regard to these secretions developed in the fertile imagination of Brown-Séquard to a great generalization, according to which every tissue of the body in the course of its normal metabolism furnishes material to the blood that is of importance in regulating the activities of other tissues. This idea found a general support in the facts brought to light in relation to the physiological activities of the so-called ductless glands, and subsequently in the series of remarkable discoveries which we owe to the new science of immunology. In recent years it has been restated in attractive form by Schiefferdecker in his theory of the symbiotic relationship of the tissues of the body. According to this author we may conceive that among the tissues of a single organism the principle of a struggle for existence, which is so important as regards the relations of one organism to another, is re-

[1] Address of the vice-president and chairman of Section K—Physiology and Experimental Medicine. American Association for the Advancement of Science, Boston, December 28, 1909.